REMARKS

Claims 1-10, 12 and 27-36 are all the claims presently pending in the Application. Claims 11 and 13-26 have been canceled. Claims 1-4, 7-8 and 12 have been amended to more particularly define the invention, and claims 27-36 have been added to claim additional features of the invention.

It is noted that the claim amendments are made only for more particularly pointing out the invention, and not for distinguishing the invention over the prior art, narrowing the claims or for any statutory requirements of patentability. Further, Applicant specifically states that no amendment to any claim herein should be construed as a disclaimer of any interest in or right to an equivalent of any element or feature of the amended claim.

Claims 1-2 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Nakamura et al. (U.S. Patent No. 5,563,422). Claims 3-6 and 12 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Nakamura in view of Okazaki (U.S. Patent No. 5,990,500). Claims 7-10 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Nakamura in view of Okazaki, and further in view of Neumann et al. (U. S. Patent No. 5,614,736).

These rejections are respectfully traversed in view of the following discussion.

I. THE CLAIMED INVENTION

The claimed invention is directed to a flip chip type of light-emitting semiconductor device which includes a substrate, group III nitride compound semiconductor layers formed on the substrate, and a positive electrode including at least one layer of a first positive electrode layer which is formed on or above a p-type semiconductor layer and reflects light toward the substrate, the first positive electrode layer being made of at least one of rhodium (Rh), ruthenium (Ru), and an alloy including at least one of these metals. The substrate transmits the light reflected from the positive electrode, and light is emitted from a substrate side of the light-emitting device.

Conventional flip chip light-emitting semiconductor devices commonly direct light through the positive electrode layer. In other words, such devices are not used to direct light through the substrate which is on the opposite side of the emission layer from the positive electrode layer.

The claimed invention, on the other hand, includes a flip-chip light-emitting semiconductor device in which the substrate transmits the light reflected from the positive electrode, and light is emitted from a substrate side of the light-emitting device. Therefore, the claimed device can be used to direct light through the substrate.

II. THE PRIOR ART REFERENCES

A. The Nakamura Reference

The Examiner alleges that Nakamura teaches the claimed invention of claims 1 and 2. Applicant submits, however, that there are elements of the claimed invention which are neither taught nor suggested by Nakamura.

Nakamura discloses a GaN-based III-V group compound semiconductor device having a Ga-N based layer over a substrate, and an ohmic electrode in contact with the semiconductor layer (Nakamura at Abstract).

However, contrary to the Examiner's allegations, Nakamura does not teach or suggest "*a positive electrode including at least one layer of a first positive electrode layer which is formed on or above said p-type semiconductor layer and reflects light toward said substrate, said first positive electrode layer comprising at least one of rhodium (Rh), and ruthenium (Ru), and an alloy including at least one of these metals*" as recited in claim 1.

As noted above, unlike conventional flip chip light-emitting semiconductor devices which commonly direct light through the positive electrode layer, the claimed device includes a positive electrode having a positive electrode layer which reflects light toward the substrate. Further, the substrate transmits the light reflected from the positive electrode, and light is emitted from a substrate side of the light-emitting device (Application at page 2, lines 18-25; Figure 1). Therefore, the claimed device can be used to transmit light through the substrate.

Specifically, the claimed device includes a positive electrode including at least one layer formed on or above a p-type semiconductor layer. The positive electrode includes a layer made of at least one of rhodium (Rh), ruthenium (Ru), and an alloy including at least one of these metals, and reflects light toward the substrate (Application at page 14, lines 2-11). The novel features of the claimed invention allow it to have a low driving voltage and a positive electrode with good reflectivity, low corrosivity, and good adhesion (Application at page 7, line 3-page 8, line 26).

Clearly, these novel features are not taught or suggested by Nakamura. Indeed, Nakamura specifically discloses a light-transmissive p-type electrode which is completely unrelated to the positive electrode of the claimed invention.

In particular, the Examiner surprisingly attempts to equate the p-electrode 15 of Nakamura with the positive electrode of the claimed invention (Nakamura at Figure 1). However, the p-electrode 15 in Nakamura is not light-reflective, but transmits light. For example, the Examiner's attention is directed to col. 6, line 41 of Nakamura which states that "[t]he p-type electrode is light-transmissive".

Further, Applicant notes that it is only sensible that the p-type electrode 15 in Nakamura is light-transmissive, considering that the device in Nakamura is not a "flip-chip" type of device. Instead, the device in Nakamura is intended to emit light from the p-type electrode. Obviously, this is completely different than the flip chip device of the claimed invention.

Applicant respectfully submits that a light-transmissive p-electrode, by definition, cannot be light-reflective. Indeed, these properties are mutually exclusive. Therefore, the Examiner's desperate attempts to equate the p-electrode of Nakamura clearly fail.

Further, even assuming (arguendo) that the "light-transmissive" p-electrode 15 may be considered "light-reflective", Nakamura clearly does not teach or suggest that the p-electrode 15 includes at least one of rhodium (Rh), ruthenium (Ru), and an alloy including at least one of these metals. Instead, the p-electrode in Nakamura is made of gold, nickel, platinum, aluminum, tin, indium, chromium, and titanium (Nakamura at col. 5, lines 43-46).

For example, Nakamura teaches that the p-electrode 15 is "produced by forming a nickel layer ... and then a gold layer ... and annealing these layers ... to alloy them and render the electrode light-transmissive" (Nakamura at col. 7, lines 35-39). Thus, the p-type electrode 15 of Nakamura clearly is formed of different materials than the positive electrode of the claimed invention.

In short, Applicant respectfully submits that forming a positive electrode which reflects lights by using one of Rh, Ru and an alloy including at least one of them is not disclosed in Nakamura''s invention. The electrode shown in Nakamura''s Figure 1 is a transparent electrode and it does not reflect light. In fact, Nakamura does not even disclose using Rh and Ru to form the electrode.

Further, as recited in newly added claim 30, in an exemplary embodiment of the claimed invention, the device may include a second thin-film metal layer including at least one of gold (Au) and an alloy including gold (Au), formed between the first thin-film metal layer and the first positive electrode layer. Specifically, the inventors have found that an Ag electrode which should have had high reflectivity and practical contact resistivity in fact has poor adhesiveness to p-GaN and has a structure of no practical use. Thus, Au/Co and Au/Ni, which function sufficiently when used to form a thin film transparent electrode, may be inserted between the Ag electrode and the p-GaN, to thereby improve adhesiveness of the electrode to the p-GaN remarkably and to maintain excellent reflectivity and contact resistivity.

In particular, a thin film made of Co or Ni may be formed at first in order to obtain adhesiveness to the p-GaN. Because Ag does not react with Co and Ni to form an alloy, it is no use to form an Ag layer directly on the Co or Ni layer to obtain adhesiveness. Since Au can react with each of Co, Ni and Ag to form an alloy or can become a solution with each of those metals, an Au thin film layer may be formed between at least one of the Co and Ni layer and the Ag layer. As a result, all the materials can be mixed and excellent adhesiveness can be obtained.

Further, because the Au/Co and the Au/Ni have sufficiently low contact resistivity toward the p-GaN, formation (e.g., lamination) of the Au/Co and the Au/Ni cannot have a detrimental effect on the contact resistivity. Also, because all the materials may be mixed with each other, a portion of an Ag layer reaches the interface of the p-GaN, to thereby obtain reflectivity close to the reflectivity when Ag is directly formed on the p-GaN.

Therefore, Applicant submits that there are elements of the claimed invention that are not taught or suggested by Nakamura. Therefore, the Examiner is respectfully requested to withdraw this rejection.

B. The Okazaki Reference

The Examiner alleges that Nakamura would have been combined with Okazaki to form the claimed invention of claims 3-6 and 12. Applicant submits, however, that these references would not have been combined and even if combined, the combination would not teach or suggest each and every element of the claimed invention.

Okazaki discloses a nitride compound light-emitting element including a metal layer (e.g., Pd, Sc, V, Zr, Hf, Ta, Rh, Ir, Co, and Cu), stacked on another metal layer (e.g., Ti, Ni, Mo, W and Mg) to increase the adhesive strength between an electrode and a semiconductor layer, and reduce the electrode contact resistance (Okazaki at Abstract).

However, Applicant submits that these references would not have been combined as alleged by the Examiner. Indeed, these references are directed to different problems and provide completely different solutions to such problems.

Specifically, the Nakamura device is directed to a device having a single layer p-electrode 15, whereas Okazaki is directed to a device having multiple metal layers (e.g., magnesium/palladium/Indium Tin Oxide (ITO)) stacked on one another. Therefore, a person of ordinary skill in the art would not have considered combining these references, absent impermissible hindsight.

Further, Applicant submits that the Examiner can point to no motivation or suggestion in the references to urge the combination as alleged by the Examiner. Indeed, the Examiner merely states that it would have been obvious to combine these references "for the purpose of improving the external quantum efficiency as taught by Okazaki" which is unrelated to a purpose (e.g., improving adhesiveness) of the claimed invention and, therefore, insufficient, to support the combination.

Moreover, like Nakamura, Okazaki does not teach or suggest "*a positive electrode including at least one layer of a first positive electrode layer which is formed on or above said p-type semiconductor layer and reflects light toward said substrate, said first positive electrode layer comprising at least one of rhodium (Rh), and ruthenium (Ru), and an alloy including at least one of these metals*" as recited in claim 1.

As noted above, unlike conventional flip chip light-emitting semiconductor devices which commonly direct light through the positive electrode layer, the claimed device includes a positive electrode having a positive electrode layer which reflects light toward the substrate. (Application at page 2, lines 18-25; Figure 1). More specifically, the positive electrode includes a layer made of at least one of rhodium (Rh), ruthenium (Ru), and an alloy including at least one of these metals (Application at page 14, lines 2-11). The novel features of the claimed invention allow it to have a low driving voltage and a positive electrode with good reflectivity, low corrosivity, and good adhesion (Application at page 7, line 3-page 8, line 26).

Clearly, these novel features are not taught or suggested by Okazaki. Indeed, Okazaki specifically discloses a transparent electrode 10 which is completely unrelated to the positive electrode of the claimed invention (Okazaki at Figure 1A; col. 4, lines 62-65).

Further, even assuming that the transparent electrode 10 in Okazaki "reflects light", clearly Okazaki does not teach or suggest a positive electrode having a layer made of at least one of rhodium (Rh), ruthenium (Ru), and an alloy including at least one of these metals, as in the claimed invention.

Therefore, Okazaki is clearly unrelated to the claimed invention. Thus, Okazaki clearly does not make up for the deficiencies of Nakamura.

In summary, Applicant notes that the claimed invention may include a first thin-film layer including Ni or Co, and a positive electrode which reflects lights to the substrate side including Rh, Ru or Ag. These features are not taught or suggested by Okazaki.

Therefore, Applicant submits that these references would not have been combined and even if combined, the combination would not teach or suggest each and every element of the claimed invention. Therefore, the Examiner is respectfully requested to withdraw this rejection.

C. The Neumann Reference

The Examiner alleges that Neumann would have been combined with Nakamura and Okazaki to form the claimed invention of claims 7-10. Applicant submits, however, that these references would not have been combined and even if combined, the combination would not teach or suggest each and every element of the claimed invention.

Neumann discloses a green light emitting diode which includes a doped semiconductor substrate wafer. A zinc-doped contact is applied to the p-conductive side of the wafer for generation of pure green light emissions. An electrically conductive layer is provided between the zinc-doped contact layer and the p-conductive wafer side to suppress diffusion of oxygen into the p-conductive wafer side during diode manufacture (Neumann at Abstract).

However, Applicant submits that these references would not have been combined as alleged by the Examiner. Indeed, these references are directed to different problems and provide completely different solutions to such problems.

Specifically, Neumann is intended to improve a green light emitting diode, which is completely unrelated to either of Nakamura and Okazaki. Therefore, a person of ordinary skill in the art would not have considered combining these references, absent impermissible hindsight.

Further, Applicant submits that the Examiner can point to no motivation or suggestion in the references to urge the combination as alleged by the Examiner. Indeed, the Examiner merely states that it would have been obvious to combine these references "for the purpose of providing a highly desirable, good ohmic contact" which is unrelated to a purpose (e.g., improving adhesiveness) of the claimed invention and, therefore, insufficient, to support the combination.

Moreover, like Nakamura and Okazaki, Neumann does not teach or suggest "*a positive electrode including at least one layer of a first positive electrode layer which is formed on or above said p-type semiconductor layer and reflects light toward said substrate, said first positive electrode layer comprising at least one of rhodium (Rh), and ruthenium (Ru), and an alloy including at least one of these metals*" as recited in claim 1. As noted above, the novel features of the claimed invention allow it to have a low driving voltage and a positive electrode with good reflectivity, low corrosivity, and good adhesion (Application at page 7, line 3-page 8, line 26).

Clearly, Neumann does not teach or suggest the limitations in the claimed combination. Indeed, Neumann does not even recognize at least one of the problems (e.g., poor luminous intensity) which the claimed invention is intended to address. Instead, Neumann is merely concerned with improving a green light emission efficiency. Specifically, Neumann merely discloses a metal layer 7 which is formed of gold or aluminum (Neumann at col. 3, lines 33-35). This is completely unrelated to the positive electrode of claimed invention.

The Examiner relies on Figure 1 in Neumann to support his allegations. However, Figure 1 merely shows a device which includes a p-type layer 3, an electrically conductive layer 4, a zinc/gold layer 5, a diffusion blocking layer 6, and a metal layer 7 (Neumann at col. 3, lines 13-43). However, nowhere does Neumann teach or suggest that any of these layers (including conductive layer 4) reflects light from an emission layer.

Thus, nowhere does Neumann teach or suggest *"a positive electrode including at least one layer of a first positive electrode layer which is formed on or above said p-type semiconductor layer and reflects light toward said substrate, said first positive electrode layer comprising at least one of rhodium (Rh), and ruthenium (Ru), and an alloy including at least one of these metals"* as recited, for example, in claim 1. Therefore, the Neumann device is completely unrelated to the claimed device.

Further, Neumann may disclose an Au electrode, but Neumann fails to teach or suggest a three-layer structure in which a Au layer is formed between a layer comprising Co or Ni and a layer comprising Rh or Ru (e.g., as recited in claim 7). Therefore, Neumann would not make up for the deficiencies of the alleged Nakamura/Okazaki combination. In addition, neither Neumann nor Onomura teaches or suggests a reflective electrode, so the references would not have been combined to form the claimed invention.

Therefore, Applicant submits that these references would not have been combined and even if combined, the combination would not teach or suggest each and every element of the claimed invention. Therefore, the Examiner is respectfully requested to withdraw this rejection.

IV. FORMAL MATTERS AND CONCLUSION

In view of the foregoing, Applicant submits that claims 1-10, 12 and 27-36, all the claims presently pending in the application, are patentably distinct over the prior art of record and are in condition for allowance. The Examiner is respectfully requested to pass the above application to issue at the earliest possible time.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary in a telephonic or personal interview.

The Commissioner is hereby authorized to charge any deficiency in fees or to credit any overpayment in fees to Attorney's Deposit Account No. 50-0481.

Respectfully Submitted,

Date: 8/12/03

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